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DESCRIPTION

Hermetic Compressor

Technical Field

The present invention relates to hermetic compressors which are used in refrigerators, air-conditioners, and refrigerating plants.

Background Art

In recent years, hermetic compressors used in refrigerating plants and others have been required to reduce the operating noises and use energy more efficiently. Japanese Patent Application Non-Examined Publication No. 2003–42064 discloses one of conventional hermetic compressors. This hermetic compressor (hereinafter referred to simply as a compressor) increases sound-deadening effect of its suction muffler, and utilizes this sound-deadening effect for increasing an amount of refrigerant circulating in the compressing room, thereby obtaining a higher energy efficiency. Another conventional one is disclosed in Japanese Patent Application Non-Examined Publication No. H11–303739. This compressor maintains refrigerant gas returned from the refrigerating cycle at a low temperature and a higher density, then the refrigerant gas is sucked into a compressing room, thereby obtaining a higher energy efficiency.

The foregoing conventional compressors are described hereinafter with reference to Fig. 6 – Fig. 8. Fig. 6 shows a sectional view of the conventional compressor, Fig. 7 shows a sectional view of a suction muffler of the conventional compressor, and Fig. 8 shows flow-rate vectors that illustrate behavior of refrigerant gas in the suction muffler of the conventional

compressor.

In Fig. 6, hermetic container 1 includes electric motor unit 5 formed of rotor 4 and stator 3 having winding 2, compressing unit 6 driven by electric motor unit 5, and oil 8 therein.

A rough structure of compressing unit 6 is described next. Crankshaft 10 includes main-shaft 11 to which rotor 4 is press-fitted, and off-center section 12 with respect to main shaft 11. Oil pump 13 is disposed inside main shaft 11 and open in oil 8. Cylinder block 20 disposed above electric motor unit 5 has cylindrical compressing room 22 and bearing 23 which rotatably supports main shaft 11. Piston 30 is inserted into compressing room 22 such that it can reciprocate in compressing room 22, and coupled to off-center section 12 via coupler 31.

Valve plate 35 seals an opening of compressing room 22, and valve plate 35 includes suction hole 38, which can communicate with compressing room 22 when suction valve 34 opens. Cylinder head 36 is rigidly disposed opposite to compressing room 22 via valve plate 35. Suction pipe 37 is fixed to hermetic container 1 and coupled to a lower pressure side (not shown) of a refrigerating cycle for guiding refrigerant gas (not shown) into container 1. Suction muffler 40 is made of synthetic resin, such as polybutylene-terephtalate to which glass fiber is added, and rigidly sandwiched by valve plate 35 and cylinder head 36.

In Fig. 7, suction muffler 40 has first communicating path 45 and second communicating path 46. To be more specific, suction muffler 40 includes sound-deadening space 43, and has second communicating path 46 of which first opening 46b communicates with hermetic container 1 and second opening 46a opens extending to sound-deadening space 43. Suction muffler 40 still has first communicating path 45 of which first opening 45b

communicates with suction hole 38 of valve plate 35 and second opening 45a opens extending to sound-deadening space 43.

Fig. 8 shows flow-rate vectors 60 which illustrate behavior of refrigerant gas in suction muffler 40. The flow-rate vectors are obtained by computer simulation. Respective vectors show a magnitude of flow-rate with their lengths, and the directions of the vectors indicate the flow directions.

Upper eddy 61 indicated by an arrow mark is formed of upward flow out of the refrigerant gas sucked from opening 46a of second communicating path 46. Lower eddy 62 indicated by another arrow mark is formed of downward flow out of the refrigerant gas sucked from opening 46a.

An operation of the foregoing conventional compressor is demonstrated hereinafter. Rotor 4 of electric motor unit 5 rotates crankshaft 10, and rotating motion of off-center section 12 is transferred to piston 30 via coupler 31, so that piston 30 reciprocates in compressing room 22. This mechanism guides refrigerant gas from the refrigerating system (not shown) through suction pipe 37 into hermetic container 1. The refrigerant gas introduced in container 1 is sucked from opening 46b of suction muffler 40 and discharged from opening 46a of second communicating path 46 into sound-deadening space 43. The discharged refrigerant gas collides against the wall of suction muffler 40 at a place nearest and facing to opening 46a, then form upper eddy 61 and lower eddy 62, and circulates in sound-deadening space 43. Then the refrigerant gas of upper eddy 61 is sucked from opening 45a into first communicating path 45, and guided to suction hole 38 punched on valve plate 35. When suction valve 34 opens, the refrigerant gas is sucked into compressing room 22, and compressed by the reciprocating motion, then discharged to the refrigerating system.

When the refrigerant is sucked into compressing room 22, the

refrigerant produces pressure pulsation, which propagates in the reversal direction to the flow of the refrigerant, i.e. from opening 45a of first communicating path 45 to sound-deadening space 43. In this case, first communicating path 45 extends into sound-deadening space 43 having high sound-deadening effect, e.g. opening 45a is situated at a node of sound of 3 – 4 kHz band which causes a noise problem, thereby obtaining high sound-deadening effect at a specific frequency band.

The pressure pulsation attenuated in sound-deadening space 43 can be further attenuated if the dimensions of sound-deadening space 43 as well as the length and inner diameter of second communicating path 46 are appropriately adjusted, which results in more effective sound-deadening.

However, in the foregoing conventional structure, the refrigerant gas is sucked from the refrigerating system (not show) into suction muffler 40 via container 1 due to reciprocating motion of piston 30, then the gas is discharged to sound-deadening space 43 through second communicating path 46. As shown in Fig. 8, the refrigerant gas does not directly flow into first communicating path 45, but collides against the wall of suction muffler 40 at nearest and facing to opening 46a, then forms upper eddy 61 and lower eddy 62, and circulates in sound-deadening space 43. The refrigerant gas returned from the refrigerating system is kept at a low temperature; however, the gas is greatly heated due to heat exchange with refrigerant gas of a high temperature in hermetic container 1 via the nearest wall. Further, the circulation flow formed of upper eddy 61 and lower eddy 62 is heated by the refrigerant gas remaining in sound-deadening space 43 because the temperature of this refrigerant gas has risen. Then the circulation flow is sucked from opening 45a of first communicating path 45 and flows into compressing room 22. As a result, compressing room 22 reduces mass-flow

rate of the refrigerant to be sucked therein, so that suction efficiency is lowered.

The refrigerant gas discharged from opening 46a of second communicating path 46 into sound-deadening space 43 forms upper eddy 61 and lower eddy 62. Fluid inertia force of the refrigerant gas sucked into sound-deadening space 43 thus substantially decreases across sound-deadening space 43 from opening 46a to opening 45a, and this reduction incurs greater pressure loss. As a result, the mass flow rate of the refrigerant gas sucked into compressing room 22 is further lowered, which aggravates the suction efficiency.

Opening 45a of first communicating path 45 is disposed closely and facing to the wall of suction muffler 40, and the pressure pulsation becomes maximum at opening 45a, so that the wall nearest and facing to opening 45a is excited. As a result, the pulsation sound of the refrigerant radiates outside suction muffler 40 to increase the noises.

Fig. 9 shows a sectional view illustrating suction muffler 50 of another conventional compressor. This another conventional compressor is described hereinafter with reference to Fig. 9. The structure of this compressor is the same as the foregoing conventional one except suction muffler 50, thus detailed descriptions of the compressor are omitted.

In Fig. 9, suction muffler 50 includes resonant space 58 which surrounds suction space 57. First communicating path 55 has a first end open to suction space 57 and a second end communicating with compressing room 22 via suction valve 34. First communicating path 55 communicates with resonant space 58 via communicating hole 59. Second communicating path 56 has a first end communicating with container 1 and a second end communicating with suction space 57.

An operation of the foregoing compressor is described hereinafter. Refrigerant gas kept at a low temperature and returned from a refrigerating system (not shown) is sucked from second communicating path 56 into suction space 57 of suction muffler 50. The gas is then sucked from first communicating path 55 into compressing room 22. At this time, since suction space 57 is surrounded by resonant space 58, suction space 57 is thermally insulated by the refrigerant gas in resonant space 58 and the wall of resonant space 58. This structure prevents the refrigerant gas in suction space 57 from being heated directly by refrigerant gas kept at a high temperature and remaining in hermetic container 1. As a result, the refrigerant gas of a high density can be sucked into compressing room 22, thereby increasing suction efficiency. Since resonant space 58 communicates with the suction space via communicating hole 59, resonant space 58 works also as a resonant space, thereby reducing noises.

However, in this conventional structure, suction space 57, which is an element of suction muffler 50, is surrounded by resonant space 58. Thus this structure prevents the refrigerant gas in suction space 57 from being heated directly by refrigerant gas kept at a high temperature in hermetic container 1, thereby increasing the suction efficiency. However, similar to the previous conventional compressor, the refrigerant gas sucked from second communicating path 56 into suction space 57 forms a large eddy before it reaches first communicating path 55, so that substantial pressure loss is produced. As a result, compressing room 22 decreases mass-flow rate of the refrigerant gas to be sucked therein, so that suction efficiency is lowered.

Suction space 57 is entirely surrounded by resonant space 58, so that suction muffler 50 as a whole becomes bulky, and needs a large number of components, or requires a complicated molding.

Disclosure of the Invention

The hermetic compressor of the present invention comprises the following elements:

a hermetic container including an electric motor unit and a compressing unit driven by the electric motor unit,

the compressing unit having a suction valve disposed at an opening of a compressing room and a suction muffler,

the suction muffler having the elements below:

a suction muffler body forming a sound-deadening space;

a first communicating path for communicating with the suction valve and with the sound-deadening space; and

a second communicating path for communicating with the hermetic container and with the sound-deadening space.

An opening of the first communicating path in the sound-deadening space and that of the second communicating path in the same space are open together in the same direction. A wall of the suction muffler body has a sound insulating wall at least on a place facing both of the openings situated in the sound-deadening space.

This structure allows suppressing the heating of the gas sucked into the suction muffler, thereby increasing the efficiency. The sound-insulating wall exerts its sound absorption capability, so that reflected wave propagating from the compressing room to the wall of the muffler body via the first communicating path is suppressed. As a result, sound transmission can be reduced.

Brief Description of the Drawings

Fig. 1 shows a sectional view of a hermetic compressor in accordance with a first exemplary embodiment of the present invention.

Fig. 2 shows a sectional view of a suction muffler in accordance with the first exemplary embodiment of the present invention.

Fig. 3 shows a perspective exploded view of the suction muffler in accordance with the first exemplary embodiment of the present invention.

Fig. 4 shows a sectional view of a suction muffler in accordance with a second exemplary embodiment of the present invention.

Fig. 5 shows flow-rate vectors in the suction muffler in accordance with the second exemplary embodiment of the present invention.

Fig. 6 shows a sectional view of a conventional hermetic compressor.

Fig. 7 shows a sectional view of a suction muffler of the conventional hermetic compressor.

Fig. 8 shows flow-rate vectors in the suction muffler of the conventional hermetic compressor.

Fig. 9 shows a sectional view of a suction muffler of the conventional hermetic compressor.

Preferred Embodiments of the Invention

Exemplary embodiments of the present invention are demonstrated hereinafter with reference with the accompanying drawings.

Exemplary Embodiment 1

Fig. 1 shows a sectional view of a hermetic compressor (hereinafter referred to simply as a compressor) in accordance with the first exemplary embodiment of the present invention.

Fig. 2 shows a sectional view of a suction muffler of the compressor in

accordance with the first embodiment. Fig. 3 shows a perspective exploded view of the suction muffler of the compressor in accordance with the first embodiment.

In Fig. 1, hermetic container 101 accommodates the following elements:

electric motor unit 105 formed of stator 103 with windings 102 and rotor 104;

compressing unit 106 to be driven by electric motor unit 105; and

oil 108 pooled therein.

Next, a rough structure of compressing unit 106 is described. Crankshaft 110 includes main-shaft 111 to which rotor 104 is press-fitted, and off-center section 112 eccentric from main shaft 111. Oil pump 113 is disposed inside main shaft 111 and open in oil 108. Cylinder block 120 disposed above electric motor unit 105 has cylindrical compressing room 122 and bearing 123 which rotatably supports main shaft 111. Piston 130 is inserted into compressing room 122 such that it can reciprocate in compressing room 122, and coupled to off-center section 112 via coupler 131.

Valve plate 135 seals an opening of compressing room 122, and valve plate 135 includes suction hole 138, which can communicate with compressing room 122 when suction valve 134 opens. Cylinder head 136 is fixed opposite to compressing room 122 via valve plate 135. Suction pipe 137 is fixed to hermetic container 101 and coupled to a lower pressure side (not shown) of a refrigerating cycle for guiding refrigerant gas (not shown) into hermetic container 101. Suction muffler 140 is made of synthetic resin, such as polybutylene-terephtalate to which glass fiber is mainly added, and rigidly sandwiched by valve plate 135 and cylinder head 136.

In Figs. 2 and 3, suction muffler 140 includes suction muffler body 141,

suction muffler lid 142, first communicating path 145, and second communicating path 146. Suction muffler 140 forms sound-deadening space 143 therein. In sound-deadening space 143, openings 145a and 146a are open in the same direction. Sound-insulating wall 151 is disposed on the wall of muffler body 141 at the place at least facing both of openings 145a and 146a. Sound insulating wall 151 and an outer wall of muffler body 141 form dual walls, which define blocked space 150. Sound-insulating wall 151 thus works as a part of suction muffler body 141 and as a wall which partitions off blocked space 150 from sound-deadening space 143.

Sound-insulating wall 151 is disposed vertically with respect to a parting surface (opening face of the muffler body) of molding the synthetic resin. After first communicating path 145 is assembled into muffler body 141, weld protrusion 145b is positioned to hole 142b punched on lid 142. Then muffler body 141 is bonded to lid 142 by a ultrasonic welding method, thereby completing suction muffler 140.

An operation of the foregoing hermetic compressor is demonstrated hereinafter. In conventional suction muffler 40, a temperature of refrigerant gas increases by approx. 10K during the travel from opening 46b to opening 45b, then the gas is sucked eventually into compressing room 22. The temperature of the refrigerant gas also increases by approx. 4K during the travel from opening 46a, where the gas is discharged into sound-deadening space 43, to opening 45a.

However, in this embodiment, blocked space 150 is formed in a part of the wall of suction muffler 140, namely, heat-insulating effect is increased at the part of the wall, so that heat-insulation is effectively obtainable with a smaller space than the conventional muffler which is entirely covered with dual walls. As a result, the refrigerant gas can be advantageously kept at a

low temperature and at a high density, thereby increasing the mass flow rate of the gas sucked.

The foregoing reduction of heating the refrigerant gas can suppress the temperature hike not more than 2K between openings 146a and 145a, so that refrigerating capacity increases by 1.5% comparing with that of the conventional muffler, and the efficiency (COP = coefficient of performance) increases by not less than 1.0%.

On the other hand, the refrigerant gas in suction muffler 140 becomes an intermittent current in response to the reciprocating motion of piston 130. At this time, pressure pulsation propagates inversely to the flow of the refrigerant gas from compressing room 22 to opening 145a of first communicating path 145, and generates reflected wave toward the wall nearest and facing to opening 145a. Sound-absorption effect of blocked space 150 formed of sound-insulating wall 151 suppresses the transmission of the reflected wave to the outside of suction muffler 140. In addition to this suppression, sound-insulating wall 151 reinforces the strength of the outer frame of suction muffler 140, thereby preventing suction muffler 140 from being excited by the reflected wave. This prevention is particularly effective to reduction of sound transmission at high-frequency component in the audible band.

Vertical placement of sound-insulating wall 151 with respect to the parting surface (opening surface of the muffler body) in molding of suction muffler 140 makes a drafting direction of the mold of muffler body 141 agree with that of sound-insulating wall 151. This structure thus prevents the molds from being complicated in drafting directions and increasing the number of components due to separating some components. As a result, the structure invites no additional cost to the molds and allows manufacturing

the suction muffler with ease.

In this embodiment, blocked space 150 formed by sound-insulating wall 151 is completely isolated from sound-deadening space 143; however, communicating holes are punched on sound-insulating wall 151 so that blocked space 150 can work as a resonant room, thereby further increasing the sound-insulating effect.

In this embodiment, sound-insulating wall 151 is disposed in suction muffler 140 for defining blocked space 150; however, a structure separate from the muffler is disposed outside the muffler so that a blocked space can be formed, thereby obtaining a similar advantage to this embodiment.

Second communicating path 146 is unitarily molded with muffler body 141; however, it can be unitarily molded with lid 142 instead, so that influence of the heat received from electric motor unit 105 disposed behind muffler body 141 can be reduced.

Exemplary Embodiment 2

Fig. 4 shows a sectional view of a suction muffler in accordance with the second exemplary embodiment of the present invention. Fig. 5 shows flow-rate vectors which show behavior of the refrigerant gas in the suction muffler in accordance with the second embodiment. The construction of a hermetic compressor (hereinafter referred to simply as a compressor) in accordance with the second embodiment is the same as shown in Fig. 1 except the suction muffler, so that the description of this embodiment focuses on the suction muffler.

In Fig. 4, suction muffler 140 includes suction muffler body 141, a suction muffler lid (not shown), first communicating path 145, and second communicating path 146, and forms sound-deadening space 143 therein. In

this embodiment, a guiding wall 152 is used as the sound-insulating wall. The guiding wall 152, shaped like letter U, guides the gas sucked from second communicating path 146, namely the refrigerant gas, from opening 146a to opening 145a.

In Fig. 5, flow-rate vectors 160 show behavior, which is obtained through computer simulation, of the refrigerant gas in suction muffler 140, and the lengths of respective vectors indicate a magnitude of flow rate as well as the directions of the vectors indicate the flow direction of the refrigerant gas. The arrow mark indicates upper stream 161 formed by the refrigerant gas discharged from opening 146a of second communicating path 146.

An operation of the foregoing hermetic compressor is demonstrated hereinafter. In this embodiment, guiding wall 152 (sound-isolating wall) is disposed for guiding the refrigerant gas discharged at opening 146a to opening 145a of first communicating path 145. This structure allows almost all the refrigerant gas discharged at opening 146a to form upper stream 161, which is then sucked into first communicating path 145. At this time, the wall of suction muffler 140 is heated by refrigerant gas kept at a high temperature in hermetic container 101, and the heated wall heats the refrigerant gas remaining in sound-deadening space 143. This heated gas has a temperature higher than that of refrigerant gas just flowing from second communicating path 146 into sound-deadening space 143.

Therefore, sucking as fast as possible almost all the refrigerant gas discharged at opening 146a into first communicating path 145 will isolate the gas from the refrigerant gas heated to a high temperature and remaining in sound-deadening space 143. This structure allows the refrigerant gas kept at a low temperature and indicated by upper stream 161 to receive a less amount of heat, so that the refrigerant gas can be kept at a low density, and

the mass flow rate of the refrigerant to be sucked can be increased.

Guiding wall 152 shapes like letter U instead of using a pipe path, so that pressure loss becomes advantageously smaller. Guiding wall 152 rectifies the refrigerant gas sucked from opening 146a so that the gas can flow smooth, and guides the gas directly to opening 145a. As a result, the pressure loss can be reduced, thereby increasing COP. Guiding wall 152 also guides the gas sucked into compressing room 122 without involving the refrigerant gas circulating in sound-deadening space 143 but using fluid inertia force of the gas sucked, so that the mass flow rate of the gas sucked is increased.

The mechanism discussed above reduces the heat reception loss of the refrigerant gas and increases the flow amount of the gas sucked, so that suction efficiency can increase, refrigerating capacity improves by 2.5% comparing with the conventional ones, and COP improves by not less than 2.0%.

There remains still a problem of reflected wave radiated from opening 145a to the nearest and confronting wall of suction muffler 140; however, guiding wall 152 covers opening 145a, thereby suppressing transmission of the reflected wave through the wall of suction muffler 140. Guiding wall 152 also prevents the reflected wave from exciting the wall of suction muffler 140. This prevention is particularly effective to reduce sound-transmission of high frequency component in the audible band.

Further in this embodiment, a clearance of approx. 5 mm is prepared between opening 145a and guiding wall 152 for maintaining attenuation effect on the reflected wave generated from opening 145a. However, coupling of opening 145a to the outer circumference of guiding wall 152 can further reducing the flow resistance of the refrigerant gas, and the suction

efficiency can be improved.

In this embodiment, descriptions of the specification identical to that of the first embodiment are omitted; however, this second embodiment can obtain the advantage of placement direction of the guiding wall with respect to the parting surface (an opening face of the suction muffler body) in molding the synthetic resin.

Industrial Applicability

A compressing unit of a hermetic compressor of the present invention includes a suction valve disposed at an opening of a compressing room and a sucking muffler. The muffler includes a suction muffler body which forms a sound-deadening space, a first communicating path which communicates with the suction valve and with the sound-deadening space, and a second communicating path which communicates with a hermetic container and with the sound-deadening space. An opening, situated in the sound-deadening space, of the first communicating path, and an opening, situated in the sound-deadening space, of the second communicating path are both open in the same direction. In addition, a sound-insulating wall is disposed on the wall of the muffler body at a place at least confronting both of the openings. Employment of this compressor in refrigerators, air-conditioners, and refrigerating plants will reduce noises and improve efficiency of those apparatuses.